U.S. Army Corps of Engineers
Portland District

Crims Island Habitat Restoration in the Columbia River Estuary-Fisheries Monitoring and Evaluation, 2003

Final Report of Research

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Executive Summary

Under the Biological Opinion, the U.S. Army Corps of Engineers (USACE) and the Bonneville Power Administration (BPA) are directed to restore over 4,047 ha (10,000 ac) of tidal marsh in the Columbia River Estuary by 2010. Restoration of Crims Island would restore 253 ha (625 ac) of tidal marsh and swamp on Crims Island in the lower Columbia River. The restoration is being initiated to improve habitat for juveniles of listed salmon stocks and Columbian white-tailed deer. The U.S. Geological Survey (USGS) conducted monitoring and evaluation of the fishery resources at Crims Island prior to restoration, which began in August 2004. Juvenile salmon research and monitoring of restoration efforts in the Columbia River estuary are supported under RPA 196 of the 2000 *Biological Opinion* and Action 6 of the Lower Columbia River Estuary Partnership (LCREP) *Comprehensive Conservation and Management Plan*, respectively.

Fish assemblages at Crims Island were primarily composed of threespine stickleback, banded killifish, subyearling Chinook salmon, and peamouth. Seasonal declines in juvenile salmon were associated with higher water temperature in the tidal marsh reference site by mid June, however fish were captured at a main-stem site through September. Residence time of subyearling Chinook salmon in Crims Island backwaters is generally short consisting of one or two tidal cycles. The median residence time of marked subyearling Chinook salmon collected in the T-channel was 5 h and ranged from 1 to 171 h. We did not recapture any fish released at the tidal marsh reference site for residence time analysis. Smaller subyearling Chinook salmon consumed adult and larval dipterans in backwater habitats and larger subyearlings consumed *Daphnia* and amphipods in pelagic habitats along Crims Island. The benthic invertebrate community at Crims Island was composed primarily of oligochaetes, chironomids, and *Corophium*. There were more benthic invertebrates in the tidal marsh reference site than in the T-channel, however, the difference was not statistically significant. Benthic invertebrates were significantly more abundant in the north backwater site than in all other sites. The drift invertebrate community was primarily composed of chironomid adults, aphids, and psocopterans, and drift organisms were significantly more abundant in the north backwater site when compared to all other sampling sites. Detritus collected in the drift was primarily composed of sticks and bark, reed canarygrass, and Eurasian milfoil.

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Acknowledgements

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Introduction

Anadromous salmon returns to the Columbia River have declined to the point where many salmon stocks originating in the lower Columbia River are now listed under the endangered species act (ESA). Under the ESA, lower Columbia River Chinook salmon and Chum salmon are designated "threatened," while Coho salmon are a candidate for listing. These declines and subsequent listings were historically associated with over harvest and more recently, with the loss of juvenile rearing habitat. In the Columbia River Estuary, the loss of tidal marsh habitat (defined as being inundated during a portion of the tidal prism) has been estimated at 8,094 ha (20,000 ac) of tidal swamp, 4,047 ha (10,000 ac) of tidal marsh, and 1,214 ha (3000 ac) of tidal flats due to diking, dredging, and filling (Northwest Power Planning Council 2001).

Under RPA 160 of the 2000 Biological Opinion, the National Marine Fisheries Service calls on the U.S. Army Corps of Engineers (USACE) and the Bonneville Power Administration (BPA) to protect and enhance at least 4,047 ha (10,000 ac) of tidal marsh habitat in the lower 74 km of the Columbia River Estuary by 2010. To address this mandate, the USACE and cooperators identified Crims Island as a site to restore 253 ha (625 ac) of tidal marsh habitat. Although Crims Island is located outside of the bounds of the Columbia River Estuary at river kilometer (rkm) 87, the island complex is strongly tidal, is currently used by juvenile salmonids, and has the potential to increase export of nutrients to the estuary. A large portion of the interior of the island was drained over 70 years ago by constructing a ditch that we refer to as the T-channel. This area was used for agriculture and cattle grazing, and the existing habitat in this area is degraded. The restoration of Crims Island involves reducing the elevation of the project area by two feet to remove invasive vegetation and allow re-establishment of a tidal marsh community. In addition, subtidal channels will be constructed to increase habitat complexity and allow for adequate water exchange between tidal cycles. This is the first effort of its kind in the lower Columbia River and little is known about the potential response of juvenile salmon to this type of habitat restoration. The USGS is currently monitoring and evaluating the pre- and post-restoration responses of the fisheries community at Crims Island.

The objectives of our study were to: 1) describe the seasonal use by juvenile salmon and other fishes of existing backwater and tidal marsh habitats at reference sites at Crims Islands, 2) describe ingress/egress of juvenile salmonids and organic matter to Crims Island backwaters and tidal marsh, 3) describe juvenile salmon diet and the invertebrate community in existing reference habitats at Crims Island, and 4) create a topographic map of the Crims Island restoration area for subsequent GIS analyses to document landscape changes.

Methods

Study Site and Sampling Locations

All sampling for this project occurred within the Crims Island complex in the tidal fluvial portion of the lower Columbia River near Clatskanie, Oregon (Figure 1). The island complex includes Crims Island, Gull Island and smaller neighboring islands which are all connected by dry land at low tide and at seasonally low river flows. The Crims Island complex is located at rkm 87 and is beyond the farthest upstream extent of salinity intrusion (Simenstad et al. 1990).

Tides at Crims Island are semi diurnal with about 7 h of ebb and 5 h of flood tide. Tidal flux ranges from 0.6 to 2.1 m as reported 1.1 km downstream of Crims Island (USGS gauge, http://waterdata.usgs.gov/nwis). We sampled at five locations within the Island complex (Figure 1). A natural tidal marsh site located on neighboring Gull Island was used as a reference site for marsh restoration on Crims Island and served as a benchmark for fisheries habitat restoration. We also established a site in the existing T-channel. This site is the only ingress/egress channel to the interior portion of Crims Island, and will provide valuable comparisons of pre and post restoration assessments. We also established two sampling sites in backwater channels to the north and east of Crims Island. Finally, we established a main-stem sampling site on the north side of Gull Island. This beach sampling site was selected to compare fish use of backwater habitats relative to the main-stem Columbia River.

Fish Abundance Sampling

Fish at Crims Island were sampled to document seasonal fish abundance and timing of habitat use. Data collection focused on juvenile salmon, however other fishes were identified and enumerated. Fish were sampled every other week from May through September, 2003 using 15m beach seines and fyke nets. Mesh size on both were 0.5 cm. Fyke nets were used to capture fish in flowing waters such as in the T-channel and northeast channel when the tides were incoming or outgoing. Beach seine sites were sampled by pulling the seine parallel to shore for a distance of roughly 50 m. Fyke nets were generally fished for 1 h. Captured fish were enumerated and scanned for marks and fin clips. The first 40 juvenile salmonids of each species and life history type were anesthetized, weighed, measured, and released. Sampling was conducted prior to restoration work in surrounding areas to describe the existing fish community with attention to predators to determine the species that will likely use the restored habitat once it is re-connected to the main river.

Concurrent with fish collections, data were collected at each site to describe the physical habitat following the methods of Key et al. (1994). The following information was collected at each beach-seine site: water depth, water velocity, and water temperature measured at a distance of 1, 7.5, and 15 m from shore. Turbidity was measured to the nearest 0.1 Nepholometric Turbidity Unit (NTU). Fish abundance was related to the existing physical habitat using correlation and frequency analyses of individual variables.

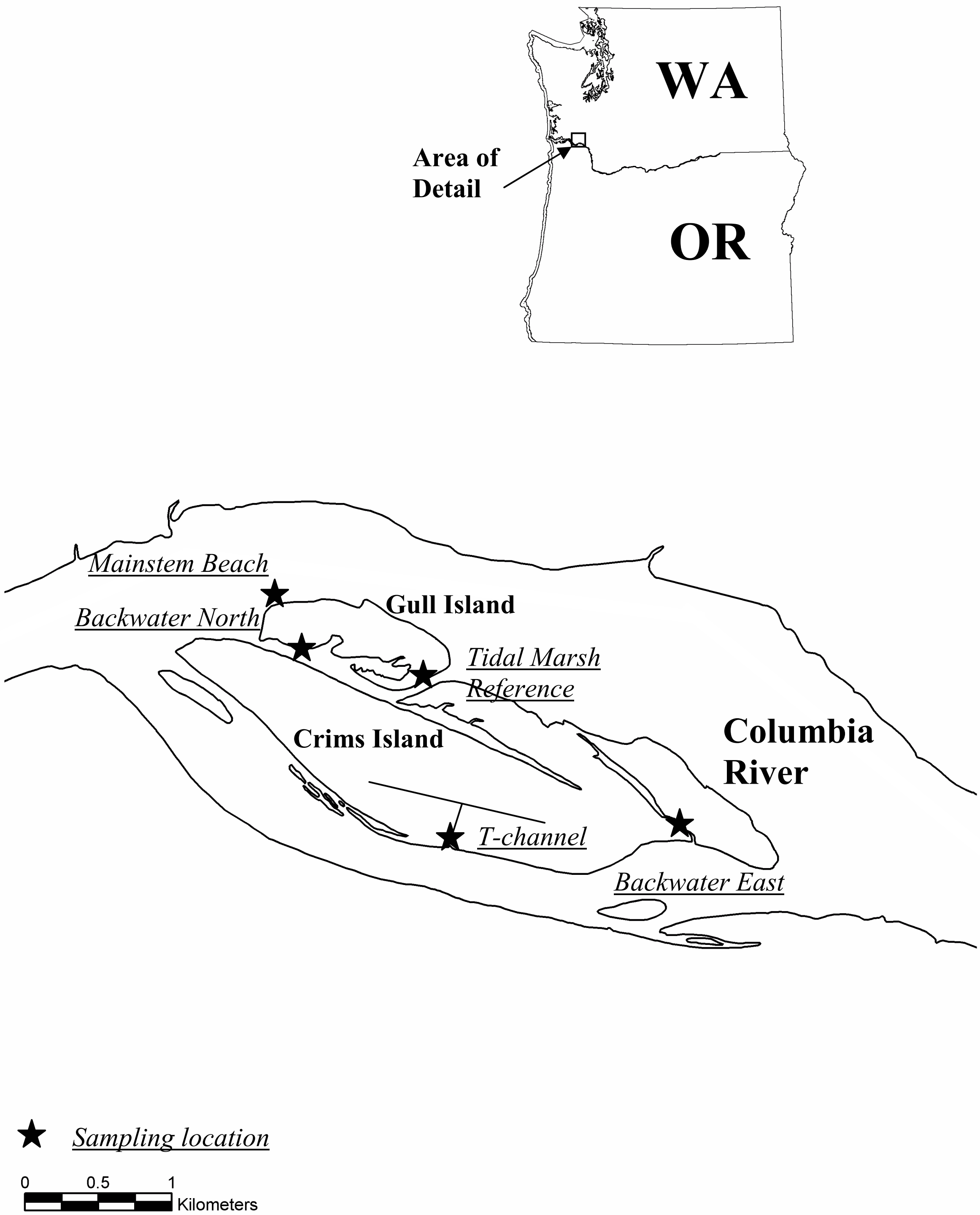

Figure 1. – Map of study area and sampling sites, Crims Island, lower Columbia River, 2003.

Residence Time

During the weeks of May 25, June 1, and June 22, we conducted mark/recapture studies at two locations at the Crims Island complex to determine juvenile salmon residence times. The first location was in the T-channel, which extends northward toward the interior of the island for 500 m and then branches east and west for approximately 500 m. Future restoration work will widen the T-channel. Anecdotal information indicates that the original T-channel was much smaller, but has widened and deepened over time.

The T-channel was sampled with a dual fyke net system, while the reference tidal marsh location was sampled with a 30 m beach seine. We marked fish with blue, black, pink, or yellow human tattoo ink at one or two of six different fin locations using a needless dental inoculator (Laufle 1990). Fins used for marking were the right pectoral, left pectoral, anal fin, dorsal fin, upper caudal fin lobe, and lower caudal fin lobe. A release group represented all marked fish from an individual fyke net. Because we fished the T-channel concurrently with two nets, two release groups were created for every hour the nets were fished. All release groups of an individual day were generally of the same color with a single or double fin mark combination representing the release group.

Dual fyke nets were suspended from a wooden beam support system and were raised and lowered with the rising and falling tide with pulleys and a hand crank mounted on both shores. Floats attached to the frame of the net modified the fyke nets for use in the deep-water channel. We attached additional netting to the bottom of each wing for our deep-water application. We also attached 0.5 cm chain to the bottom of the wings to add weight and ensure that the bottom of the net was in contact with the bottom of the channel. In this manner, the nets could simultaneously collect fish moving either with or against the prevailing tide. Fish were collected from both nets at 1.5 h intervals. A Marsh-McBirney flow meter was affixed to the mouth of each net and the water velocity was generally recorded at 15-min intervals. The T-channel site was a closed system with only a single entry/exit point, and using this system we could potentially collect every fish that was entering or exiting the T-channel.

Captured fish were anesthetized with MS-222, measured, weighed, and marked. Each group collected from an individual net haul was given a distinct fin/color mark combination. Fish were allowed to recover for 5 min before release. Fish were released 40 m north or south of the direction in which they were traveling (beyond the net in which they were captured). Recaptured fish were not remarked, but were anesthetized, measured, weighed, and released.

We also attempted to determine the residence time of juvenile salmon at the tidal marsh reference site on Gull Island. The USACE proposed early on to use the tidal marsh reference site as a "model" for restoration to be completed on Crims Island. The tidal marsh reference site was an open system with multiple entry and exit locations at high tide. We sampled the tidal marsh reference site with a 30 m beach seine between the period encompassing 1 h before and after high tide. We used this period because the tidal marsh reference site was typically dry and/or inaccessible by boat at other times. Fish captured in the tidal marsh reference site were anesthetized with MS-222, weighed, measured, and released at the point of capture.

Stomach Sampling

Once a month, we collected stomach contents from 20 fish of subyearling Chinook salmon using non-lethal lavage in the T-channel and the main-stem beach site. The lavage instrument was a 30 ml syringe with a 100 µL pipette tip affixed to the end. Each fish was anesthetized and the pipette tip inserted to the head of the stomach. Distilled water was used to flush the contents of the stomach into a Whirl-Pak and was frozen on dry ice for subsequent analyses. In the past, USGS personnel have used this technique to successfully remove up to 93% of the stomach contents of Chinook salmon as small as 42 mm in both the Snake and Columbia rivers.

Invertebrate and Detrital Sampling

We sampled invertebrates from the surface drift and the benthos at the tidal marsh reference site, the northern backwater and the eastern backwater locations (Figure 1). Each month, 10 benthic cores were collected from each site using 174.6-cm^3 PVC coring device (McCabe and Hinton 1996). The samples were treated as replicates to analyze the benthic invertebrate community and preserved in a 95% ethanol solution for laboratory analysis.

We collected detritus and invertebrates from the surface drift with three replicate drift samples at each site using a metered 150-micron mesh drift net with a mouth opening of 35 x 50 cm. The sampling frame and net were towed through the water at a constant boat speed for a period of 10 min. A General Oceanics flow meter attached inside the mouth of the net was used to calculate volume sampled. Captured organisms and detritus were preserved in 95% ethanol. Invertebrates and detritus were identified to the lowest practical taxon and enumerated in the laboratory. Taxonomic categories were dried for 24 h at 55 ^{0}C and weighed.

Data Analysis

Fish, benthic and drift invertebrate catch between major habitat types (e.g., backwater, channel, etc.) and seasonal sampling periods were compared using two-way analysis of variance (ANOVA) with habitat type and seasonal sampling period as the main effects. Interactive effects between sampling period and sampling site were examined prior to the main effects. The mean number of taxa, mean number of individuals per taxa (organisms $\cdot$ m^{-2}), and standard deviation (SD) for each sampling site were calculated. Normal probability plots and plots of residual versus predicted means were used to assess the assumptions of normality and non-constant variance, respectively (SPSS 2000). All fish and invertebrate abundances were transformed prior to statistical analysis to normalize distributions. When interactive effects were detected in an ANOVA, main effects were analyzed separately using one-way ANOVA.

Two community structure indices were used as a measure of diversity between sampling sites. The first was the Shannon-Weiner index for Diversity (H) which is defined as:

$$\sum_{I=1}^{k} H= -3\, p_i \log p_i$$

where k = number of categories (taxa) and p_i = the number of observations in a category/sample.

The second index was Evenness (E), which expresses the observed diversity as a proportion of the maximum possible diversity, ranging from 0 to 1, with 1 indicating all taxa from a sample are numerically equivalent.

$$E = H/\log k$$

where H=Shannon-Weiner index and k= number of categories (taxa).

Organisms from fish stomachs were identified and enumerated to the lowest practical taxon. The number, weight, and frequency of occurrence of prey items were used to determine the importance of prey items, using the Index of Relative Importance (IRI) (Pinkas et al. 1971). IRI values were then converted to percentages (McCabe et al. 1986; Muir and Emmett 1988) with high percent IRI values indicating greater importance of a food group among prey taxa. IRI is defined as:

$$IRI = F\,(N+W)$$

where F = frequency of occurrence of a prey item, W = percent weight of a prey item, and N = percent number of a prey item.

Results

Fish Abundance

Fish assemblages at Crims Island were primarily composed of threespine stickleback (*Gasterosteus aculeatus*), banded killifish (*Fundulus diaphanous*), subyearling Chinook salmon (*Oncorhynchus tshawytscha*), and peamouth (*Mylocheilus caurinus*). Three-spine stickleback was the most abundant fish collected in seine and fyke net hauls, representing over 56% of the total catch (Table 1). Exotic fishes represented half (8 of 16) of the species collected at Crims Island in 2003. Exotic banded killifish, which is native east of the Yellowstone River, represented over 35% of the total catch, and generally were the most predominate fish in backwaters when water temperature exceeded 25°C. Banded killifish eat chironomid larvae, cladocerans, and copepods. They spawn in weedy backwaters when water temperature exceeds 23°C (Scott and Crossman 1973).

Juvenile Salmonid Abundance and Size

Seasonal abundance of subyearling Chinook salmon at Crims Island was highest in late April to early May, but by late June fish were primarily found only at the main-stem beach site (Figures 2-3). Declining abundance of subyearling Chinook was associated with increasing water temperature. As water temperature exceeded 20°C at backwater sampling sites, Chinook salmon abundance declined and few were captured at water temperatures above 22°C. Small numbers of fish persisted in the main-stem beach location through July and August.

Subyearling Chinook salmon varied in size between sampling locations (Figure 4). Fish were smallest at the north and east backwater sites averaging less than 50 mm. Mean subyearling fork lengths were similar (between 55-60 mm) at the T-channel and tidal marsh reference sites. However, there was more variation in fish size in the T-channel than at the tidal marsh reference site. Fish were largest (mean=69 mm) at the main channel site on the Columbia River and exhibited the greatest variation in size.

Table 1. – Scientific name, common name, life stage, percent occurrence, and percent of total fishes collected with beach seines and fyke nets at Crims Island, lower Columbia River, 2003.

Scientific name	Common name	Life stage	Percent occurrence	Percent of total
Catostomidae				
Catostomus macrocheilus	Largescale sucker	Both	6.1	0.03
Centrarchidae				
Lepomis macrochirus[1]	Bluegill	Juv	8.0	0.09
Pomoxis nigromaculatus[1]	Black crappie	Juv	19.0	0.17
Lepomis gibbosus[1]	Pumpkinseed	Both	14.1	0.14
Micropterus salmoides[1]	Largemouth bass	Juv		<0.01
Clupeidae				
Alosa sapidissima[1, 2]	American shad	Juv	4.3	-
Cottidae				
Cottus bairdi	Mottled sculpin	Adult	14.1	0.10
Cyprinidae				
Cyprinus carpio[1]	Common carp	Adult	0.6	0.01
Ptychocheilus oregonensis	Northern pikeminnow	Both	40.5	0.77
Mylocheilus caurinus	Peamouth	Both	55.8	2.23
Fundulidae				
Fundulus diaphanus[1]	Banded killifish	Both	77.3	35.55
Gasterosteidae				
Gasterosteus aculeatus	Threespine stickleback	Both	90.2	56.41
Percidae				
Perca flavescens[1]	Yellow perch	Both	17.2	0.15
Pleuronectidae				
Platichthys stellatus	Starry flounder	Juv	7.4	0.10
Salmonidae				
Oncorhynchus tshawytscha	Yearling Chinook salmon	Juv	2.5	0.01
Oncorhynchus tshawytscha	Subyearling Chinook salmon	Juv	61.3	3.83
Oncorhynchus kisutch	Yearling Coho salmon	Juv	1.2	<0.01
Oncorhynchus kisutch	Subyearling Coho salmon	Juv	2.5	0.01
Oncorhynchus keta	Chum salmon	Juv	1.2	<0.01

[1] Non native species
[2] Presence/absence only

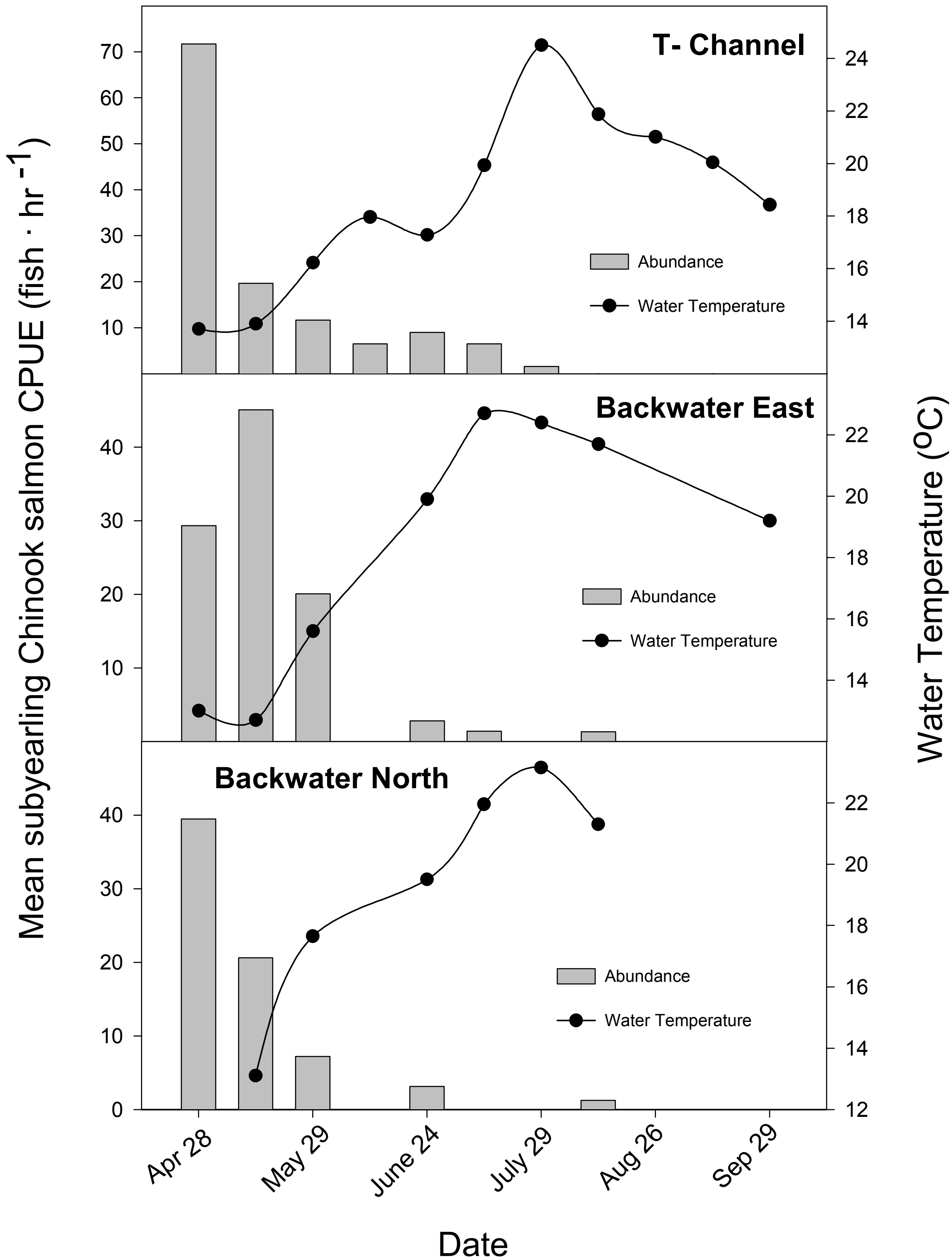

Figure 2. - Seasonal variation in subyearling Chinook salmon CPUE and water temperature collected at three stations, Crims Island, lower Columbia River, 2003.

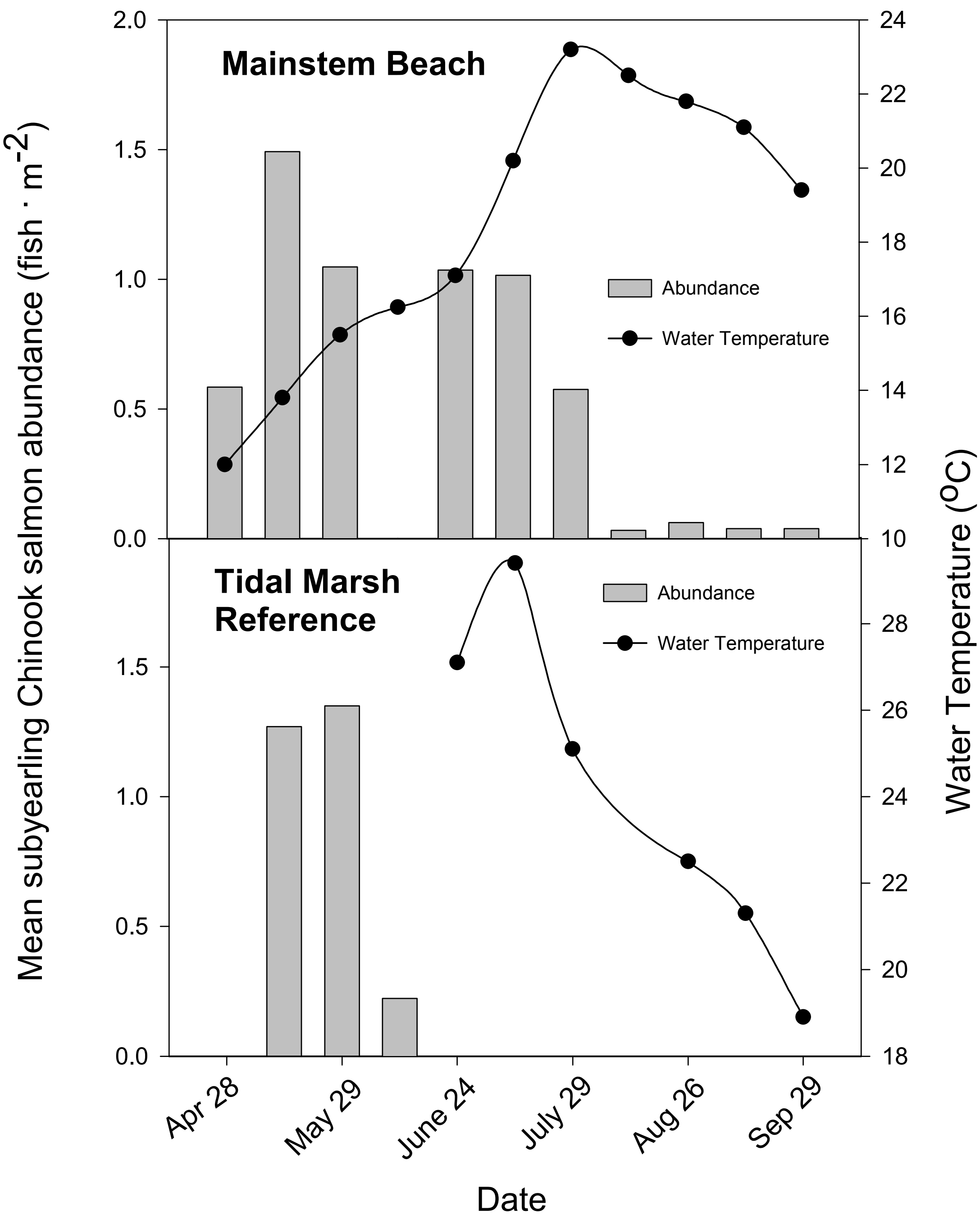

Figure 3. - Seasonal variation in subyearling Chinook salmon abundance (fish · m^{-2}) and water temperature collected at two stations, Crims Island, lower Columbia River, 2003.

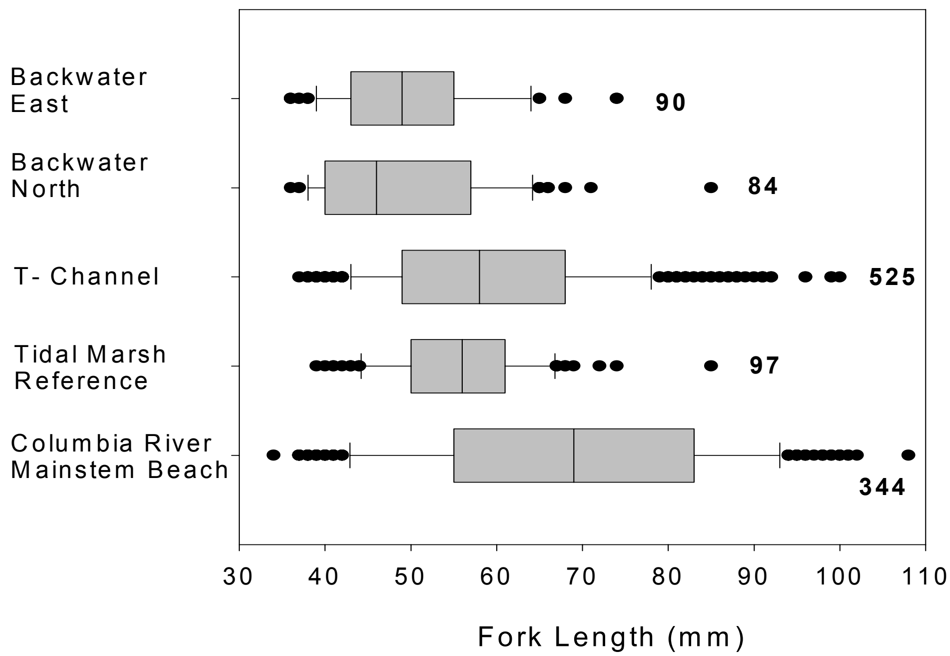

Figure 4. Fork length characteristics of subyearling Chinook fork length collected from five different locations at Crims Island, April-September 2003. Data is presented in quartile distribution with outliers and the total number sampled.

Residence Time

During our three sample periods, we marked and released 222 and 50 subyearling Chinook salmon in the T-channel and tidal marsh reference sites, respectively. In the T-channel, we recaptured 32 fish from previous net hauls of the same sample period, but recaptured no fish from previous sample periods. No fish were recaptured in the tidal marsh reference site. The median residence time of marked subyearling Chinook salmon collected in the T-channel was 5 h and ranged from 1 to 171 h (Figure 5). We did not recapture any fish released at the tidal marsh reference site.

Tidal Variation in Fish Abundance

Fish movement through the T-channel was generally with the prevailing tide; however, our data indicate that some fish do move against the tide when water velocity exceeds 10 $cm \cdot s^{-1}$ (Figures 6-8). Water velocity in the T-channel ranged from 0 to 18 $cm \cdot s^{-1}$ on the flood tide (measured at the south net) and from 0-7 $cm \cdot s^{-1}$ on the ebb tide (measured at the north net). We detected movement against the tide primarily in the evening hours and our data suggest that subyearling Chinook exit backwaters before nightfall.

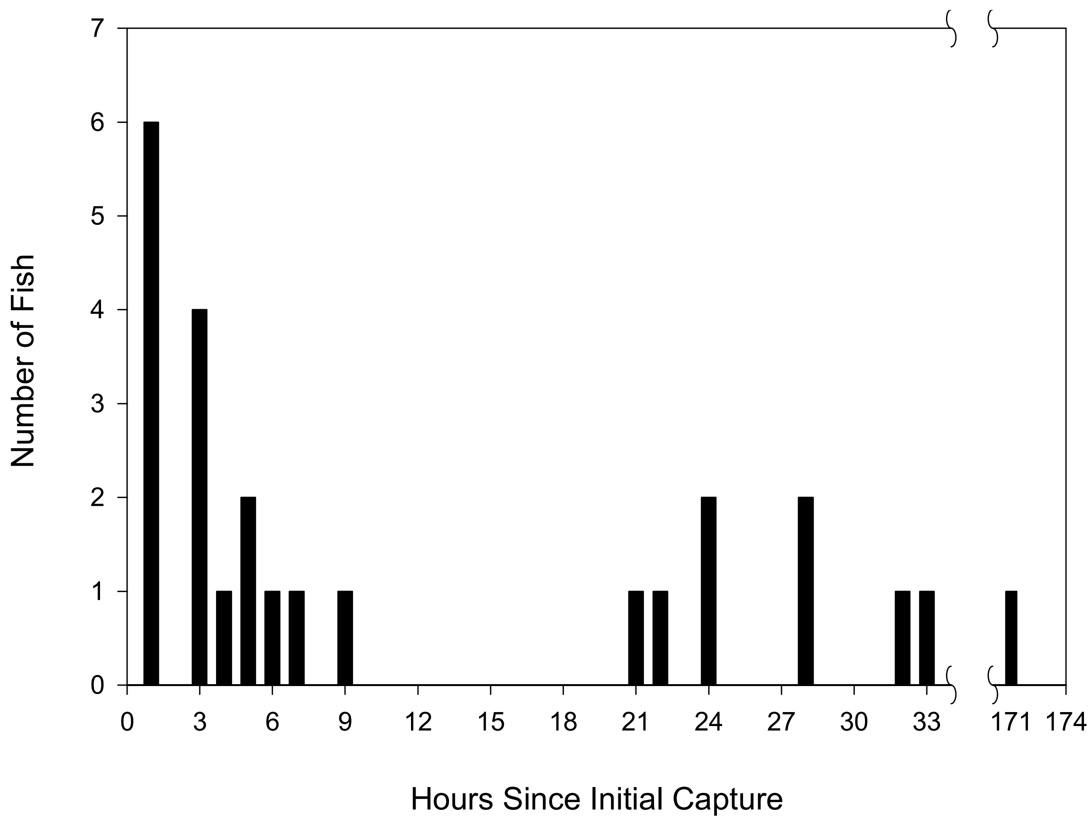

Figure 5. Minimum residence time of subyearling Chinook collected from the T-channel at Crims Island, May 30-June 7, 2003. Numbers of fish are recaptures marked with tattoo ink and a needless inoculator.

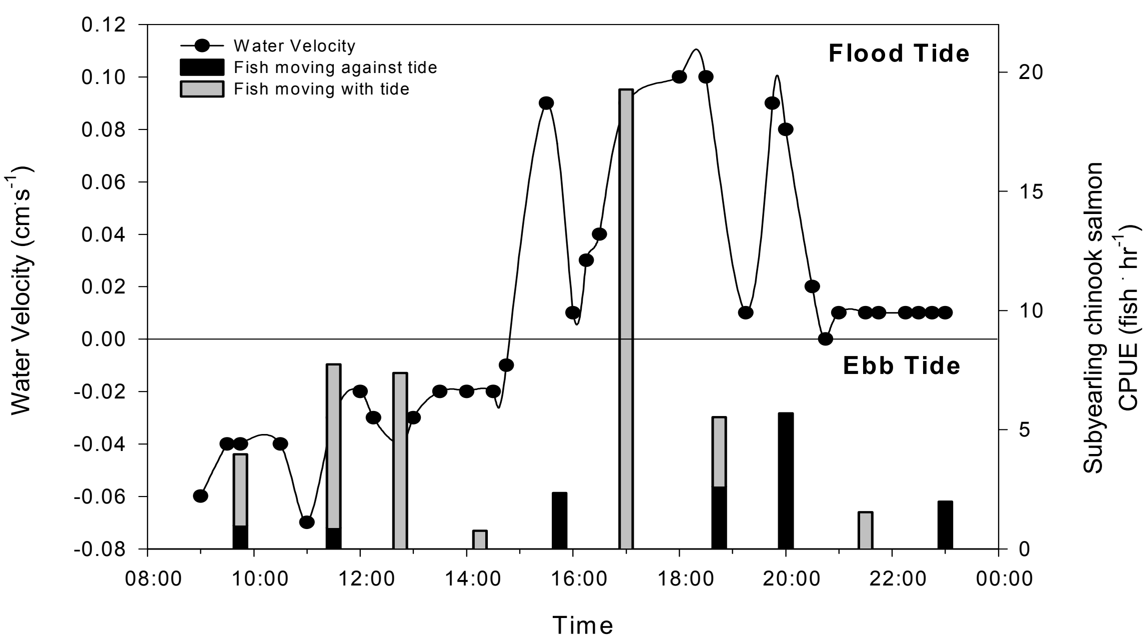

Figure 6. – Time series of subyearling Chinook CPUE and water velocity across an ebb and flood tide using paired fyke nets located in the T-channel of Crims Island on June 5, 2003.

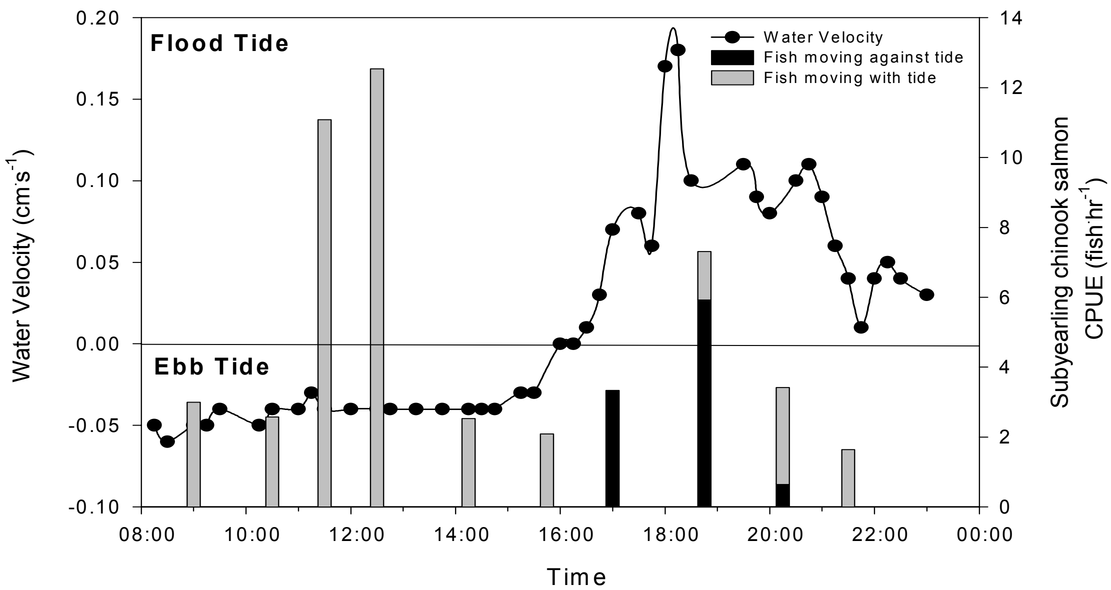

Figure 7. – Time series of subyearling Chinook CPUE and water velocity across an ebb and flood tide using paired fyke nets located in the T-channel of Crims Island on June 6, 2003.

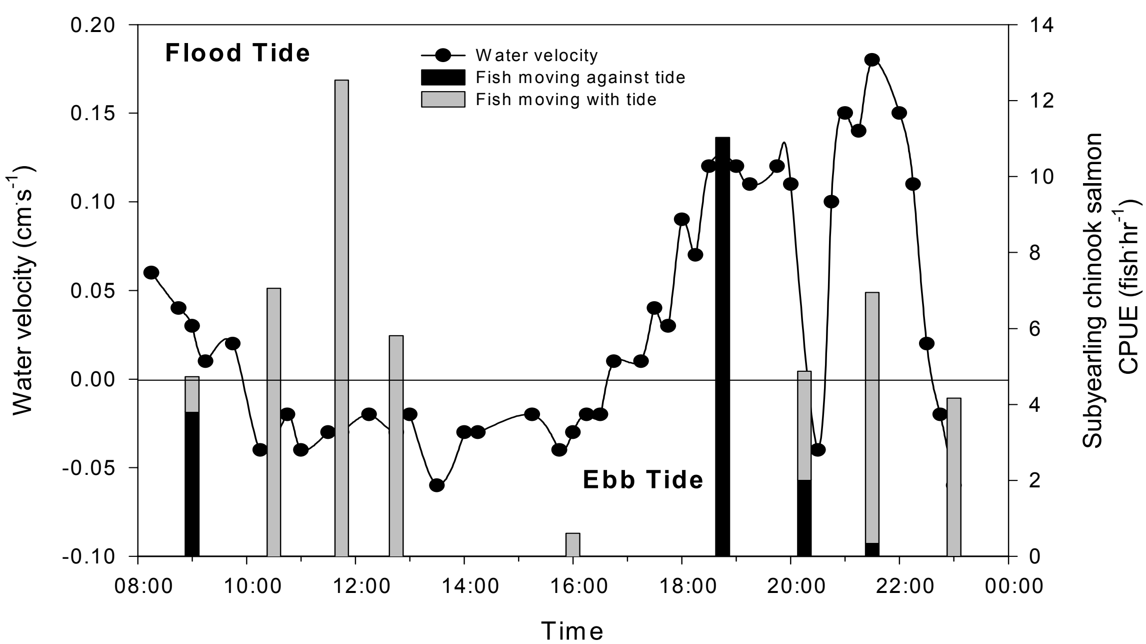

Figure 8. – Time series of subyearling Chinook CPUE and water velocity across an ebb and flood tide using paired fyke nets located in the T-channel of Crims Island on June 7, 2003.

Stomach Content Analysis

Subyearling Chinook salmon preferentially preyed on amphipods, dipterans, and cladoceran zooplankton, however, food preference varied by location and by sampling site (Table 2). *Corophium spinicorne* was the primary amphipod consumed, dipteran prey consisted predominately of chironomid adults and larvae, and *Daphnia* were the main cladoceran zooplankton prey consumed. At the main-stem beach sampling location, feeding shifted from predominately *Corophium* earlier in the sampling season to cladoceran zooplankton later in the season. During the second sampling period, subyearling Chinook salmon fed primarily on chironomids in the T-channel site and *Corophium* and *Daphnia* in the main-stem beach site. In the second sampling period at the T-channel site, chironomids represented the greatest percentage of subyearling Chinook salmon diets followed by juvenile sticklebacks. We observed a large number of spawning adult sticklebacks in the T-channel during June and July. Newly hatched sticklebacks are a seasonally abundant food source for juvenile salmon, but as sticklebacks grow they likely become unsuitable as prey to juvenile salmon because of their large dorsal spines.

Table 2. Sample site, date, total number of stomachs (N), number of empty stomachs (E), and percent IRI of food items collected from stomach contents of subyearling Chinook salmon at Crims Island in 2003. Taxa with IRI values less than 0.3 were not included in this table.

Site	Date	N	E	Amph-ipoda	Clado-cera	Dip-tera	Fish[1]	Homo-ptera	Hymen-optera	Mysid-acea
Beach	April 28	19	2	89.0	-	9.8	-	0.3	0.5	0.3
T-channel	July 8	13	2	6.5	-	61.6	40.0	-	-	-
Beach		20	2	18.0	73.7	8.3	-	-	-	-
Beach	July 30	16	0	5.3	92.7	2.0	-	-	-	-

[1] All fish are juvenile sticklebacks (Gasterosteidae)

Benthic Invertebrates

The benthic invertebrate community at Crims Island was composed primarily of oligochaetes, chironomids larvae, and *Corophium* (Table 3). Total benthic invertebrate abundance ranged from 1,031 m^{-2} to 12,284 m^{-2}. The number of taxa ranged from 2 to 9, Diversity (H) ranged from 0.12 to 0.74 and Evenness (E) ranged from 0.46 to 0.90. All three indices were generally greatest in the T-channel (Table 4) indicating that the T-channel that overall the T-channel had the greatest number of taxa, the greatest diversity, and relatively equal proportional abundances of benthic invertebrate taxa. Overall, there were more benthic invertebrates in the tidal marsh reference site than in the T-channel, however, the difference in means was not statistically significant. Because of a significant interaction between the sampling site and sampling period, we ran two, one-way ANOVA's and examined the effect of site and period on benthic invertebrate abundance individually. Benthic invertebrates were significantly more abundant in the north backwater site than in all other sites. The significant interaction revealed that the effect of sampling site on benthic invertebrate abundance is dependent on sampling period.

Table 3. Scientific name, total number, percent occurrence, and percent of total benthic invertebrates collected at Crims Island, lower Columbia River, 2003.

Scientific name	Total number	Percent occurrence	Percent of total
Amphipoda			
Corophiidae			
Corophium salmonis	121	21.11	9.81
Corophium spinicorne	60	6.67	4.86
Corophium spp.	3	4.07	4.13
Gammaridae	3		0.24
Coleoptera			
Elmidae	6	2.22	0.49
Decapoda			
Astacidea			
Pacificus connectens	1	0.37	0.08
Diptera			
Ceratopogonidae	29	8.89	2.35
Chironomidae	322	51.85	26.12
Unknown	1	0.37	0.08
Gastropoda	19	4.81	1.54
Nematoda	37	10.37	3.00
Odonata			
Coenagrionidae	1	0.37	0.08
Oligochaeta	501	58.89	40.63
Ostracoda	5	0.74	0.41
Pelecypoda			
Margaritiferidae			
Corbicula fluminea[1]	52	14.07	4.22
Polychaeta	24	8.51	1.95

[1] Non native species

Table 4. – Station, date, total number of invertebrates, mean abundance (number · m^{-2}), standard deviation (SD), number of taxa, diversity, and evenness of the benthic invertebrate community at Crims Island, Columbia River, June 24 through September 29, 2003. Ten replicates were collected at each station.

Site	Date	Mean abundance	SD	Total	Number of taxa	Diversity (H)	Evenness (E)
Beach	6/24	5583	3761	65	4	0.34	0.56
Reference	6/24	6700	4649	78	7	0.53	0.62
T-channel	6/24	2319	3389	27	4	0.45	0.74
Backwater East	7/10	12284	8028	143	6	0.51	0.65
Backwater North	7/10	6356	4691	74	3	0.31	0.64
Reference	7/10	3436	1515	40	6	0.57	0.74
T-channel	7/10	3780	3417	44	8	0.58	0.65
Backwater East	7/30	3178	3712	37	7	0.72	0.86
Backwater North	7/30	3264	2522	38	7	0.56	0.66
Reference	7/30	4123	3183	48	5	0.56	0.81
T-channel	7/30	5240	4625	61	7	0.74	0.87
Backwater East	8/13	2405	975	28	5	0.58	0.83
Backwater North	8/13	2319	1944	27	4	0.39	0.65
Reference	8/13	3178	3413	37	4	0.40	0.66
T-channel	8/13	1117	815	13	5	0.62	0.88
Backwater East	8/26	2663	1429	31	3	0.37	0.78
Backwater North	8/26	3865	2075	45	3	0.37	0.77
Reference	8/26	1031	975	12	3	0.39	0.81
T-channel	8/26	2233	1727	26	2	0.12	0.39
Backwater East	9/10	773	1245	9	3	0.46	0.97
Backwater North	9/10	10566	7199	123	9	0.64	0.67
Reference	9/10	2921	1864	34	6	0.52	0.67
T-channel	9/10	3694	1767	43	7	0.68	0.80
Backwater East	9/29	1374	1160	16	4	0.53	0.87
Backwater North	9/29	6185	5245	72	4	0.28	0.46
Reference	9/29	3006	2114	35	4	0.46	0.76
T-channel	9/29	2405	1802	28	5	0.63	0.90
MEAN	-	**3926**	**2935**	**46**	**5**	**0.49**	**0.73**

Drift Invertebrates

The drift invertebrate community was primarily composed of chironomid adults, aphids, and psocopterans (Table 5). Drift invertebrate density ranged from 0.02 to 0.41 m^{-2}. The number of taxa ranged from 7 to 34, Diversity (H) ranged from 0.54 to 1.41, and Evenness (E) ranged from 0.43 to 0.89. Two-way analysis of variance indicated that sampling period (p=0.0024, F=4.45) and sampling site (p=0.0019, F=5.87) were both significant in relation to overall drift invertebrate abundance. A Student-Newman-Keuls means test revealed that drift invertebrates were significantly more abundant in the north backwater site when compared to all other sampling sites (Table 6). These tests also indicated that mean abundances of drift invertebrates in the tidal marsh reference site were not significantly different from those in the T-channel.

Detritus

Detritus collected in the drift was primarily composed of sticks and bark, reed canarygrass, and Eurasian milfoil (Table 7). Although many different species had high frequencies of occurrence, terrestrially derived wood in the form of sticks and bark and unidentifiable debris comprised the greatest percentages by weight. Also of importance by weight were reed canarygrass and Eurasian water-milfoil, both of which are non native species. Each only represented about 4% of the total detrital export by weight, however, these percentages are relatively large because much of the debris category consisted of items and pieces that were unidentifiable because of there small size.

Table 5. Scientific name, life stage, percent occurrence, and percent of total of drift invertebrates collected at Crims Island, lower Columbia River, 2003.

Taxa	Life stage	Percent occurrence	Percent of total
Amphipoda			
Corophiidae			
Corophium salmonis	Aquatic	15.27	0.67
Corophium spinicorne	Aquatic	13.89	0.48
Corophium spp.	Aquatic	1.39	0.03
Gammaridae	Aquatic	1.39	0.16
Gammarus	Aquatic	31.94	7.04
Anisogammarus	Aquatic	2.78	0.06
Araneae	Terrestrial	40.28	1.62
Coleoptera			
Coccinellidae	Terrestrial	4.17	0.13
Curculionidae	Aquatic	6.94	0.19
Dryopidae	Aquatic	1.39	0.03
Dytiscidae	Aquatic	1.39	0.03
Elateridae	Terrestrial	1.39	0.03
Elmidae	Aquatic	8.33	0.25
Haliplidae	Aquatic	5.56	0.13
Hydrophilidae	Aquatic	5.56	0.13
Staphylinidae	Aquatic	26.39	0.95
Collembola			
Entomobryidae	Aquatic	47.22	2.89
Hypogastruridae	Aquatic	20.83	1.01
Sminthuridae	Aquatic	20.83	0.95
Dermaptera			
Forficulidae	Terrestrial	1.39	0.03
Diptera	Aquatic	51.39	2.16
Canaceidae	Aquatic	1.39	6.40
Ceratopogonidae	Aquatic	66.67	6.40
Chironomidae	Aquatic	90.28	29.52
Dolichopodidae	Aquatic	4.17	0.10
Dryomyzidae	Aquatic	1.39	0.03
Ephydridae	Aquatic	1.39	0.03
Muscidae	Aquatic	2.78	0.06
Sarcophagidae	Aquatic	2.78	0.10
Sciomyzidae	Aquatic	58.33	4.09
Tipulidae	Aquatic	26.39	1.17
Ephemeroptera	Aquatic	4.17	0.10
Gastropoda	Aquatic	15.28	0.48
Hemiptera	Aquatic	15.28	0.60
Belostomatidae	Aquatic	1.39	0.03
Corixidae	Aquatic	19.44	1.08
Gerridae	Aquatic	2.78	0.06
Miridae	Terrestrial	8.33	0.29
Pentatomidae	Terrestrial	1.39	0.03
Saldidae	Aquatic	23.61	1.17
Homoptera	Aquatic	4.17	0.16
Aphididae	Terrestrial	80.56	14.71
Cicadellidae	Terrestrial	25.00	1.05
Membracidae	Terrestrial	1.39	0.03
Hydracarina	Aquatic	11.11	0.25
Hymenoptera	Terrestrial	6.94	0.16
Apidae	Terrestrial	4.17	0.10

Braconidae	Aquatic	37.50	1.46
Diapriidae	Aquatic	19.44	0.73
Eucoilidae	Aquatic	6.94	0.22
Eulophidae	Aquatic	20.83	0.76
Formicidae	Terrestrial	22.22	0.86
Ichneumonidea	Aquatic	6.94	0.16
Mymaridae	Aquatic	4.17	0.10
Pteromalidae	Aquatic	2.78	0.06
Scelionidae	Aquatic	40.28	1.30
Vespidae	Terrestrial	2.78	0.06
Lepidoptera	Aquatic	13.89	0.38
Noctuidae	Aquatic	6.94	0.16
Mysidacea			
Mysidae			
Neomysis mercedis	Aquatic	5.56	0.16
Odonata			
Coenagrionidae	Aquatic	36.11	1.46
Oligochaeta	Aquatic	13.89	0.48
Pelecypoda			
Corbiculidae			
Corbicula fluminea[1]	Aquatic	2.78	0.06
Psocoptera			
Psocidae	Terrestrial	62.50	6.53
Thysanoptera			
Aeolothripidae	Terrestrial	2.78	0.10
Thripidae	Terrestrial	18.06	0.48
Trichoptera			
Hydroptilidae	Aquatic	1.39	0.03
Limnephilidae	Aquatic	1.39	0.03
Unknown	-	4.17	0.03

[1]Non native species

Table 6. – Station, date, total number of invertebrates, mean abundance (number · m^{-2}), standard deviation (SD), number of taxa, diversity, and evenness of the drift invertebrate community at Crims Island, Columbia River, July 7 through September 29, 2003. Three replicates were collected at each station.

Station	Date	Total	Mean abundance	SD	Number of taxa	Diversity (H)	Evenness (E)
Backwater East	7/10	106	0.56	0.06	18	0.54	0.43
Backwater North	7/10	126	0.13	0.07	20	0.89	0.69
Reference	7/10	51	0.33	0.09	17	0.98	0.80
T-channel	7/10	65	0.28	0.14	23	1.09	0.80
Backwater East	7/30	117	0.10	0.04	21	0.90	0.68
Backwater North	7/30	155	0.12	0.05	24	0.98	0.71
Reference	7/30	110	0.19	0.17	24	1.08	0.78
T-channel	7/30	237	0.30	0.09	31	0.87	0.58
Backwater East	8/13	245	0.28	0.04	32	1.10	0.73
Backwater North	8/13	86	0.25	0.21	20	1.02	0.79
Reference	8/13	186	0.39	0.45	24	0.81	0.59
T-channel	8/13	209	0.33	0.09	41	1.41	0.87
Backwater East	8/26	38	0.11	-	12	0.83	0.77
Backwater North	8/26	135	0.21	0.09	24	0.88	0.63
Reference	8/26	116	0.28	0.10	21	0.99	0.75
T-channel	8/26	61	0.23	-	21	1.09	0.75
Backwater East	9/10	271	0.30	0.10	29	1.09	0.75
Backwater North	9/10	25	0.02	0.01	7	0.67	0.79
Reference	9/10	117	0.22	0.07	18	0.84	0.67
T-channel	9/10	250	0.41	0.18	34	1.11	0.73
Backwater East	9/29	83	0.07	0.03	24	1.21	0.88
Backwater North	9/29	32	0.02	0.00	13	0.99	0.89
Reference	9/29	109	0.12	0.07	16	0.74	0.62
T-channel	9/29	224	0.25	0.14	30	1.04	0.71
MEAN	**-**	**131**	**0.23**	**0.10**	**23**	**0.96**	**0.72**

Table 7. – Scientific name, common name, percent occurrence, and percent total weight of detritus collected with drift sampler at Crims Island, Columbia River Estuary in 2003.

Scientific name	Common name	Aquatic or terrestrial	Percent occurrence	Percent of total weight
Alismataceae				
Alisma triviale	American water plantain	Aquatic	4.48	0.10
Sagittaria sp.	Arrowhead	Aquatic	8.96	0.11
Betulaceae				
Alnus rubra	Red alder	Terrestrial	26.87	1.06
Ceratophyllaceae				
Ceratophyllum demersum	Coontail	Aquatic	22.39	0.18
Cornaceae				
Cornus sp.	Dogwood	Terrestrial	16.42	0.20
Cyperaceae				
Eleocharis sp.	Needle spike-rush	Aquatic	41.79	1.67
Scirpus sp.	Hardstem bulrush	Aquatic	14.93	1.23
Carex sp.	Sedge	Aquatic	1.49	0.11
Fontinalaceae				
Fontinalis antipyretica	Common water moss	Aquatic	2.99	0.04
Haloragaceae				
Myriophyllum spicatum[1]	Eurasian water-milfoil	Aquatic	71.64	4.01
Hydrocharitaceae				
Elodea nuttallii	Nuttall's waterweed	Aquatic	49.25	1.42
Onaraceae				
Ludwigia palustris	Water purslane	Aquatic	2.99	0.01
Poaceae				
Phalaris arundinaceae[1]	Reed canarygrass	Terrestrial	35.82	4.41
Potamogetonaceae				
Potamogeton crispus	Curly leaf pondweed	Aquatic	47.76	0.58
Potamogeton sp.	Pondweed species	Aquatic	28.36	1.35
Rosaceae				
Crataegous douglasii	Black hawthorn	Terrestrial	17.91	0.20
Rubus armeniacus[1]	Himalaya blackberry	Terrestrial	1.49	0.03
Salicaceae				
Populus trichocarpa	Black cottonwood	Terrestrial	23.88	2.37
Salix sp.	Willow species	Terrestrial	40.30	1.29
Scrophulariaceae				
Gratiola ebracteata	Bractless hedge-hyssop	Aquatic	4.48	0.01
Unknown leaves		Terrestrial	4.48	0.11
Wood[2]		Terrestrial	16.42	30.48
Debris[3]			98.51	49.01

[1] Non native species
[2] Sticks and bark
[3] Unidentifiable leaf pieces, stems, seeds, filamentous algae, and decomposed plant matter

Discussion

Our sampling found that the primary salmonid using habitats at Crims Island are subyearling Chinook salmon. We collected very few other salmonids, however we did not begin sampling until the end of April, which may have resulted in low catch of other species such as chum salmon that may migrate seaward earlier in the season. Most subyearling Chinook salmon collected were less than 80 mm fork length and appeared to used all the different habitats we sampled for rearing. As fish grow in size, there may be a greater propensity for fish to begin to move further off shore and downriver as has been observed by others (Dauble et al. 1980). Our capture of post-emergent subyearlings (38-40 mm) suggests that some fish are able to locate and enter Crims Island habitats soon after emergence from upstream spawning locations. Restored habitats on Crims Island will likely benefit these small fish by providing areas of warmer water temperatures where feeding and growth can be optimized.

Our mark-recapture efforts to determine fish residence time showed that fish do not remain in Crims Island habitats for extended periods of time. However, our results may have been affected by the number of fish we were able to mark and release, and the relatively poor habitat conditions in the T-channel. The steep-sided banks of the T-channel are not typical of the lower sloped shorelines that subyearling Chinook salmon typically prefer (Tiffan et al. 2002). In addition, the amount of available habitat is not great, particularly at low tide. Restoration efforts will expand available habitat and construct them more in accordance with preferred habitat criteria. This may increase the residence time of fish in restored habitats. However, we showed that as water temperature increased, fish catch declined. The period of greatest seasonal use of Crims Island habitats was in the spring and continued through June, after which time temperatures became too high to support rearing juvenile salmon. However, we did initiate sampling until late April and we probably missed peak juvenile salmonid abundance in Crims Island backwaters (Rich 1920).

During our reconnaissance sampling, we collected data that indicated juvenile salmon movement into and out of backwaters is not always with the prevailing tide. Therefore, we modified our collection of juvenile salmon in backwaters to sample fish moving in either direction. A design in which fish were only sampled as they moved with the prevailing tide would bias results, blocking the passage of fish that would otherwise move past the sampling location against the prevailing tide. Coho salmon smolts implanted with ultrasonic transmitters in the lower Coos Bay estuary predominately moved with the direction of tidal flow (Miller and Sadro 2003). Our data suggests that many fish exit backwaters as evening approaches and enter the main river channel regardless of flow direction. Subyearling Chinook salmon are visual daytime feeders and it is likely they are entering Crims Island backwaters to feed during daylight hours. Although numbers of recaptures of marked fish were small for our 2003 marking study, our data suggest that subyearling Chinook salmon residence time in individual backwaters is short, but may be of benefit given the quality of habitat and food resources found there.

In our study, we used CPUE as a surrogate for estimating total population size. Using CPUE as an indication of population size is generally adequate when trying to detect changes in abundance greater than 50 individuals (Pine et al. 2003). These numbers provide a relative abundance at distinct sites, and are very useful for comparisons over time, however, they make site comparisons tenuous because CPUE estimates from a fyke net are not directly comparable to CPUE or number-per-area estimates from a beach seine. Therefore comparisons cannot be made between sites that have different habitat types and are sampled using different gears. We propose to circumvent this problem in our 2004 sampling by calculating the volume of water sampled at our fyke net sites.

Subyearling Chinook salmon consumed primarily chironomids in the T-channel of Crims Island, the most abundant prey item in the drift. Subyearlings in the Hanford Reach of the Columbia River and the Hells Canyon Reach of the Snake River also feed heavily (50% of diet) on chironomids (Becker 1973; USGS unpublished data), and are important to fish growth in these areas. Subyearlings are opportunistic feeders and will exploit any abundant food source. It is likely that chironomids will make up a large portion of the food resources available to juvenile salmonids in post-restoration habitats on Crims Island. Terrestrial Homopterans are also important to subyearling Chinook salmon in the Snake and Columbia rivers (USGS unpublished data), but were not abundant in subyearling stomachs at Crims Island in spite of being abundant in the drift. It is possible that chironomids are more preferred than Homopterans at Crims Island, but exploitation of Homopterans may increase after restoration because there will be more vegetated shoreline areas that increase the opportunity of these organisms to enter the drift. Juvenile salmon primarily feed on chironomids in backwaters at Crims Island; however, in the mainstem their primary food source is *Corophium* and *Daphnia*. It is likely that food will not be limited in restored habitats on Crims Island.

The restoration of Crims Island will likely convert the degraded T-channel, which passes through a monoculture stand of reed canarygrass, into a series of intertidal channels with a diverse plant assemblage consisting of rushes and sedges as are present at the reference site on Gull Island. The establishment of emergent vegetation on Crims Island will increase detrital export to the estuary. Major changes have occurred in detrital pathways that historically existed in the Columbia River Estuary. First, overall detrital exports have been reduced due to the loss of emergent vegetation and benthic algae in the lower Columbia River. Second, phytoplankton biomass has increased substantially after the construction of dams and reservoirs. Reservoir-produced phytoplankton is now transported downstream to the estuary and has partly replaced nutrient input that historically came from emergent vegetation (Prahl et al. 1997; Bottom et al. 2001). Organic carbon is now primarily supplied through autochthonous microdetritus derived from phytoplankton assemblages, whereas historically it was supplied through allochthonous macrodetritus derived from emergent vegetation (Sherwood et al. 1990) including large woody debris (LWD). The restoration of Crims Island will increase the growth and subsequent export of emergent vegetation to the estuary and help restore estuarine food webs.

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Appendix

Table A.1. – Release Date, Fork Length (FL), Capture direction of travel (WT= With Tide, AT= Against Tide), release time, recapture date, recapture time, Recapture direction of travel (WT= With Tide, AT= Against Tide), and residence time of subyearling Chinook marked at Crims Island in May-June, 2003.

Release Date	FL (mm)	Capture Enter/Leave (WT, AT)	Release Time (hr)	Recap Date	Recap Time (hr) [1]	Recapture Enter/Leave (WT, AT)	Residence Time (hr)
5/30/03	59	Leave (WT)	1120	5/30/03	1415	Enter (WT)	3:00
5/30/03	55	Leave (WT)	1120	5/30/03	1415	Enter (WT)	3:00
6/5/03	59	Enter (AT)	1135	6/5/03	1504	Leave (WT)	3:29
6/5/03	58	Leave (WT)	1630	6/5/03	1631	Leave (AT)	-
6/5/03	60	Leave (WT)	1250	6/5/03	1628	Leave (AT)	3:38
6/5/03	82	Leave (WT)	1135	6/5/03	1628	Leave (AT)	4:53
6/5/03	57	Leave (WT)	1250	6/5/03	1754	Enter (WT)	5:04
6/5/03	59	Leave (WT)	1630	6/5/03	1754	Enter (WT)	1:24
6/5/03	56	Leave (WT)	1630	6/5/03	1754	Enter (WT)	1:24
6/5/03	61	Leave (WT)	1250	6/5/03	1802	Leave (AT)	5:12
6/5/03	64	?	?	6/5/03	1802	Leave (AT)	-
6/5/03	60	Leave (AT)	1825	6/5/03	1928	Enter (WT)	1:03
6/5/03	54	Leave (AT)	1825	6/5/03	1928	Enter (WT)	1:03
6/5/03	71	Leave (WT)	1250	6/5/03	1928	Enter (WT)	6:38
6/5/03	55	Leave (AT)	1936	6/5/03	1937	Enter (WT)	-
6/5/03	59	Leave (AT)	1825	6/5/03	1928	Enter (WT)	1:03
6/5/03	68	Leave (WT)	1250	6/5/03	2225	Leave (AT)	9:35
6/5/03	78	Leave (WT)	1135	6/6/03			-
6/5/03	69	Leave (WT)	1135	6/6/03	1204	Leave (WT)	24:29
6/5/03	49	Leave (WT)	1135	6/6/03	1204	Leave (WT)	24:29
6/5/03	52	Leave (WT)	1135	6/6/03	1633	Leave (WT)	28:58
6/5/03	82	Leave (AT)	1825	6/6/03	1633	Leave (WT)	22:08
6/5/03	77	Leave (WT)	1307	6/6/03	1803	Leave (AT)	28:56
6/5/03	59	Enter (WT)	2056	6/6/03	1803	Leave (AT)	21:07
6/6/03	88	?	?	6/6/03	1944	Enter (WT)	-
6/6/03	78	?	?	6/6/03	1944	Enter (WT)	-
6/5/03	61	Leave (WT)	1135	6/6/03	2056	Enter (WT)	33:21
5/30/03	86	Leave (WT)	1120	6/7/03	1506	Leave (WT)	171:46
6/7/03	69	Leave (AT)	1942	6/7/03	1943	Enter (WT)	-
6/7/03	57	Leave (AT)	1942	6/7/03	1943	Enter (WT)	-
6/7/03	63	Leave (AT)	1942	6/7/03	1943	Enter (WT)	-
6/7/03	54	Leave (WT)	1208	6/7/03	1925	Enter (WT)	7:13
6/7/03	61	Leave (AT)	2104	6/7/03	2105	Enter (WT)	-
6/6/03	68	Leave (WT)	1158	6/7/03	2053	Enter (WT)	32:55
6/7/03	66	Leave (AT)	1942	6/7/03	2053	Enter (WT)	1:11

Table A.2. – Release date, time, number of fish, mark, fork length, weight, location, and number of recaptures of subyearling Chinook salmon released at Crims Island, lower Columbia River in 2003. Mark locations codes are: A=Anal, D=Dorsal, LP=Left Pectoral, RP=Right Pectoral, UC= Upper Caudal, and LC= Lower Caudal.

Release Date	Release Time	No. of Fish	Mark Color (Location)	Mean Fork Length (range mm)	Mean Weight (range g)	Release Location	No. of Recaps
06/04/03	16:30	1	Blue (LP)	52	2.0	South T-Channel	
06/04/03	20:08	4	Blue (A, D)	56 (49-61)	2.08 (1.4-2.6)	South T-Channel	
06/04/03	19:55	6	Blue (RP, LP)	60.3(52-68)	2.7 (1.8-3.9)	South T-Channel	
06/04/03	20:57	1	Blue (D, UC)	56	2.3	South T-Channel	
06/04/03	22:47	1	Blue (D, LC)	64	2.8	South T-Channel	
06/04/03	23:04	1	Blue (A, LC)	45	0.9	South T-Channel	
06/05/03	7:30	16	Black (LP)	61.9(53-72)	3.4(2.0-5.1)	Beach	
06/05/03	9:52	1	Black (RP)	56.5	2.2	South T-Channel	
06/05/03	10:00	3	Black (AF)	51(47-54)	1.8(1.4-2.1)	North T-Channel	
06/05/03	11:30	1	Black (D)	59	2.4	South T-Channel	
06/05/03	11:35	8	Black (UC)	62.5(55-88)	3.49(1.9-8.9)	North T-Channel	
06/05/03	12:50	8	Black (LC)	62.8(53-91)	3.7(2.0-9.2)	North T-Channel	
06/05/03	14:15	1	Black (RP, LP)	56.0(55-58)	2.5(1.7-3.3)	North T-Channel	
06/05/03	16:30	3	Black (D, UC)	57.0(52-62)	2.5(1.8-2.5)	North T-Channel	1
06/05/03	18:25	23	Black (A, LC)	66(47-96)	3.7(1.2-10.2)	North T-Channel	4
06/05/03	19:30	1	Black (A, UC)	49	1.4	South T-Channel	3
06/05/03	19:36	3	Black (D, LC)	56(46-64)	1.8(1.3-2.1)	North T-Channel	2
06/05/03	20:56	2	Black (A, RP)	61(54-71)	3.5(3.2-3.8)	North T-Channel	5
06/05/03	22:25	1	Black (A, D)	81	6.7	North T-Channel	1
06/05/03	22:45	3	Black (UC, LP)	74.3(68-81)	5.2(3.2-7.2)	North T-Channel	
06/06/03	7:00	5	Pink (D)	61.5(41-85)	3.6(0.8-8.0)	Ref Tidal Marsh	
06/06/03	9:36	3	Pink (A, D)	65.0(57-78)	3.5(2.2-5.6)	North T-Channel	
06/06/03	10:55	3	Pink (D, UC)	68.0(59-78)	4.4(2.6-6.9)	North T-Channel	
06/06/03	11:58	12	Pink (D, LC)	71.1(61-100)	5.0(2.9-13.8)	North T-Channel	
06/06/03	13:07	11	Pink (A, UC)	68.9(49-99)	4.6(1.4-12.4)	North T-Channel	3
06/06/03	14:42	4	Pink (LP, UC)	69.8(54-99)	4.5(1.7-9.6)	North T-Channel	
06/06/03	16:20	3	Pink (A)	75(63-88)	5.2(3.0-7.9)	North T-Channel	
06/06/03	17:54	3	Red (LP)	68.2(52-82)	3.9(2.4-5.2)	North T-Channel	2
06/06/03	19:35	2	Red (RP)	69.5(68-71)	3.9(3.9)	South T-Channel	
06/06/03	19:45	7	Red (A, LC)	67.4(53-81)	3.8(2.0-6.7)	South T-Channel	2
06/06/03	21:02	2	Red (LP, RP)	83.0(78-88)	7.0(5.6-8.0)	South T-Channel	
06/06/03	21:06	1	Red (UC, RP)	51	1.5	North T-Channel	
06/06/03	22:15	1	Red (UC)	53	1.6	South T-Channel	1
06/07/03	7:13	12	Green (D)	62.3(55-74)	3.1(1.9-4.6)	Ref Tidal Marsh	
06/07/03	9:42	4	Green (A, LC)	68.5(59-80)	3.7(2.1-6.0)	Ref Tidal Marsh	
06/07/03	10:58	8	Green (A, D)	63.4(51-70)	3.3(1.7-5.2)	North T-Channel	
06/07/03	12:08	12	Green (UC, D)	66.8(42-91)	4.2(1.2-9.9)	North T-Channel	
06/07/03	13:18	6	Green (LC, D)	66.0(58-73)	4.0(2.3-5.5)	North T-Channel	
06/07/03	16:30	0				North T-Channel	1
06/07/03	19:42	16	Green (UC)	72.9(59-96)	4.7(2.0-10.6)	North T-Channel	
06/07/03	20:56	0				South T-Channel	4
06/07/03	21:04	3	Green (RP)	62(55-70)	2.5(1.6-3.6)	North T-Channel	
06/07/03	22:32	6	Green (UC)	65.4(55-77)	2.9(2.0-4.2)	South T-Channel	3
06/07/03	23:38	1	Green (A)	59	2.4	North T-Channel	
06/07/03	23:36	5	Green (A)	67.8(59-76)	3.7(2.4-5.1)	North T-Channel	
06/24/03	15:31	1	Yellow (LC)	75	4.5	North T-Channel	
06/24/03	17:27	5	Yellow (UC)	68.8(56-81)	4.3(2.8-6.1)	North T-Channel	
06/24/03	18:59	10	Yellow (A)	75.7(70-83)	5.0(3.7-6.8)	North T-Channel	
Totals		**234**		**60.2(41-100)**	**3.2(0.8-13.8)**		**32**